CLAIMS

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1. A method of forming a high spatial resolution perspective rendering from a low spatial resolution voxel data set, comprising:

(a) raycasting at least one ray from a predetermined location into the voxel space, by sampling points along said ray in a space defined by said voxel data set;

(b) accumulating the effect of opacity along the ray path, using opacity values at said sampling points, into a ray storage value;

(c) associating points along the cast ray with material classes, each material class of a plurality of possible material classes being associated with a set of opacity values;

(d) determining if a ray passes from a point in a first material class to a point in a second material class, using on the opacity values of the points;

(e) providing at least one association of a boundary visualization value with a boundary between two different material classes;

(f) if the ray is determined to pass between classes, accumulating a boundary visualization-value associated with a boundary between the two classes into said ray storage value; and

(g) repeating at least (a), (b), (d), and (f) for a plurality of cast rays; and

(h) forming a high spatial resolution perspective rendering from said determining ray storage values.

2. A method according to claim 1, comprising determining the location of said boundary in (f) during said ray casting.

3. A method according to claim 2, wherein said boundary is set to be at a position between said two points of different classes.

4. A method according to claim 2, wherein said boundary is determining by examining at least one addition sampling point between the two points of different classes.

5. A method according to claim 4, comprising repeating examining sampling points between points of different classes, until a desired precision of boundary determination is achieved.

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6. A method according to any of claims 1-5, comprising calculating said boundary visualization value during said ray casting.

7. A method according to claim 6, wherein determining a boundary visualization value comprises determining a normal to said boundary at said point.

8. A method according to any of claims 1-6, comprising:

providing an index array indicating for at least some of said voxels if a class-boundary does not pass near the voxel.

9. A method according to claim 8, comprising:

avoiding said determining in (d) if a sampled point has a negative indication in said index array.

10. A method according to claim 8, comprising:

reusing an opacity value from a previous sampled point a sampled point has a negative indication in said index array.

11. A method according to claim 8, wherein said index array is generated by setting a value indicating a lack of a boundary for all voxels that are surrounded by voxels in a same class.

12. A method according to any of claims 1-11, wherein said associated boundary visualization value comprises a surface lighting calculation of said boundary.

13. A method according to any of claims 1-12, comprising stopping said ray casting if said accumulated opacity is over a threshold.

14. A method according to any of claims 1-13, wherein said sampling points are separated by a step size and wherein said step size is dependent on the opacity value at the sampling points.

15. A method according to claim 14, wherein said step size is always smaller than a voxel cross-section along the path of the cast ray.

16. A method according to claim 14, wherein said step size is dependent on a opacity at a currently sampled point.

17. A method according to claim 14, wherein said step size is dependent on the opacities of neighboring voxels to the currently sampled point.

18. A method according to any of claims 1-17, comprising providing a definition of voxel value intervals for each class, prior to said ray casting.

19. A method according to any of claims 1-18, comprising:
interpolating between voxels near said point; and
transforming said interpolated voxel value into an opacity value for said point.

20. A method according to claim 19, wherein said interpolation is dependent on a distance between said sampled point and said vantage point.

21. A method according to claim 20, wherein said interpolation varies between a cubic interpolation for nearby points and a linear interpolation for far points.

22. A method according to any of claims 1-21, wherein said predetermining location is within the voxel space.

23. A method according to any of claims 1-22, wherein said voxel data set comprises a medical imaging data set.

24. A method according to any of claims 1-23, wherein (g) comprises:
sparely casting rays; and
determining if to cast at least one additional ray between cast rays.

25. A method according to claim 24, wherein determining if to cast said at least one additional ray comprises determining if said neighboring rays to said additional ray have statistically homogeneous ray storage values.

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26. A method according to claim 25, wherein statistical homogeneity is determined with respect to the ray storage values.

27. A method according to claim 25 or claim 26, wherein statistical homogeneity is determined with respect to depth factors associated with the ray.

28. A method according to any of claims 1-27, wherein (h) comprises interpolating between stored values of cast rays.

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29. A method according to any of claims 1-27, wherein (g) comprises progressively increasing the density of raycasting.

30. A method according to claim 29, wherein the progressively cast rays are cast in parallel.

31. A method according to claim 29, wherein additional cast rays are cast to progressively generate nested levels of resolution in the formed image.

32. A method according to any of claims 1-31, comprising rendering said formed perspective rendering on a display.

33. A method according to any of claims 1-32, comprising defining a window in or near the voxel space through which to cast said rays.

34. A method according to claim 33, wherein said window is perpendicular to a provided orientation vector.

35. A method according to claim 33 or claim 34, wherein said window is flat and rectangular.

36. A method according to claim 33 or claim 34, wherein said window is curved.

37. A method according to claim 33-36, wherein said window is defined by pixels in a uniformly spaced rectangular grid.

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38. A method according to claim 33-36, wherein said window is defined by pixels using coordinates which are one of circular coordinates, elliptical coordinates and another conic projection of coordinates.

39. A method according to any of claims 1-38, wherein said accumulation of opacity comprises updating a storage value CT as follows: CT=CT*T^step_size, where T is a transparency value corresponding to the opacity value.

40. A method according to any of claims 1-39, wherein said rays are cast in parallel.

41. A method according to any of claims 1-40, wherein the voxel data set is generated by one of CT (Computerized Tomography), MRI (Magnetic Resonance Imaging), Ultrasound, a geophysical survey, a meteorological survey, a scientific simulation, an animation model having more than two dimensions and a set of simultaneous equations.

42. A method according to any of claims 1-41, wherein each voxel has associated therewith a visual representation value and comprising:

determining a visualization value associated with a sampled point from the voxel associated visual representation values; and

accumulating said point associated visualization value into said stored value.

43. A method according to claim 42, wherein said visual representation value is a gray scale value.

44. A method according to claim 42, wherein said visual representation value is a color value.

45. A method according to any of claims 42-44, wherein accumulating said point associated visualization values comprises selectively accumulating values based on front surface detection.

46. A method according to any of claims 42-45, wherein said point associated visualization value comprises a volume lighting value.

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47. A method according to any of claims 42-46, wherein said point associated visualization value comprises a surface lighting value.

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48. A method according to any of claims 1-47, wherein advancing along a ray is coordinated with an opacification process.

49. Apparatus for forming a perspective rendering from a voxel space including:

(a) a memory for storing a voxel data set;

(b) a computer processor for applying the method of any of the claims 1-48 to said stored data set to form said perspective rendering; and

(c) a second memory for storing said formed perspective rendering.

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